Analysis and Design of an Algorithm for Optimization of Frequent Pattern Mining

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

to

Manav Rachna International Institute of Research and Studies
(Deemed to be University)

by

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Registration number: 18/PhD/62

Under the supervision of

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FACULTY OF COMPUTER APPLICATIONS

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ABSTRACT

Data Mining is used for extraction of useful patterns from huge datasets that may help in decision making. Frequent Pattern Mining (FPM) is very focused research area in data mining over a decade. FPM is used in association rule mining and other data mining tasks. Frequent Patterns are patterns those occur very frequently in dataset. As there are existing algorithms for FPM like Apriori, Fp Growth, Eclat, P-eclat, SDFEM, and FP-ICA. In Apriori algorithm , there is need of multiple scanning of datasets for generation of candidate itemsets . But in Fp-Growth algorithm dataset is scanned two times to form Fp-tree. In Fp Growth huge memory consumption is done to hold the fp tree for Frequent Pattern Mining. In this era of big data, these limitations are more prominent to deal with large datasets. A comparative study of some existing FPM algorithms and their variations has been analyzed to find the limitations of these algorithms. Based on the study a new algorithm will be proposed which should be more scalable and efficient in terms of time and memory. This algorithm will be developed by pruning irrelevant itemsets to deal with Frequent Pattern Mining. In addition to this, proposed algorithm will be framed into parallel and distributed environment to balance the workload of single node by using hadoop technology. Efficiency and scalability both parameters will be improved by using distributed and parallelization on bigdatasets. Real time datasets will be used to validate proposed algorithm and compare the result of proposed algorithm with the existing Frequent Pattern Mining algorithms.

Keywords: Frequent Pattern Mining (FPM), Fp-growth, Fp-tree, Association, Pruning, hadoop, Parallelization, Big datasets.

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1. INTRODUCTION

Data Mining is a technique used for extraction of meaningful and useful information from collection of huge datasets. Useful and required information can't get directly from the database as it seems. Data mining is a complex process which is the collection of some simple steps. The various steps of data mining process are data cleaning, data integration, data selection, data transformation, data mining, pattern evaluation and knowledge representation .These steps should be followed in the same order. With the quick increment in measurement and open databases in different zones, it seems very simple to consider how to mine the data from enormous measure of data. Knowledge extraction in database targets to find the significant data from enormous collection of data. With the mining of knowledge in data bases, large data bases fill in as a reliable source for knowledge and the mined data can be helpful to numerous applications, for example, query processing, decision making, etc. Different clients consider data mining as another utilized term known as KDD (Knowledge Discovery and Data Mining). Figure 1 shows the different steps of knowledge extraction in data mining.

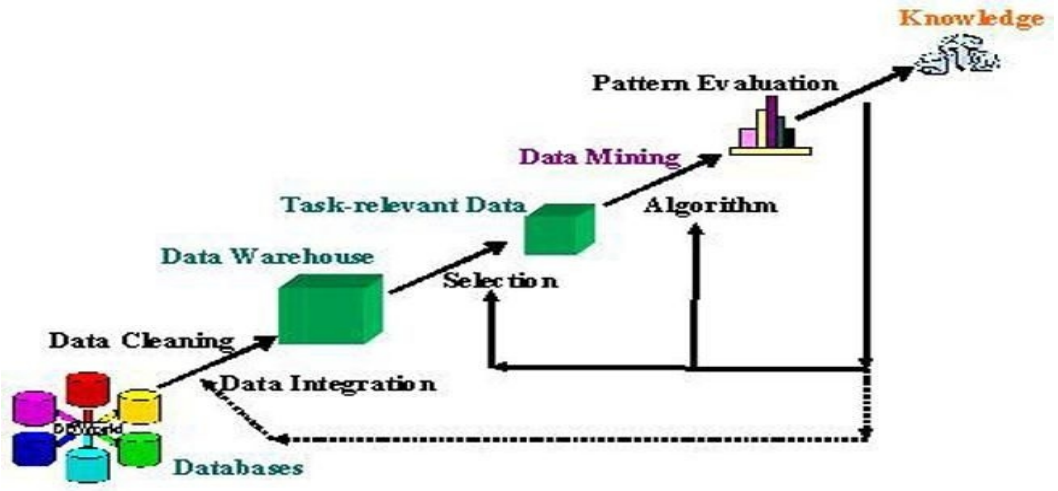

Figure 1 : Knowledge Discovery and Data Mining (Source: Han and Kamber 2001).

Data Mining Process

Data Mining processes are divided into seven steps:

a) Data Cleaning : Data gets cleaned in the data preparation. Real time data is always incomplete ,inconsistent and noisy. Many times data available does not include attributes we required. For example, if we need of demographic data of clients and the attribute of gender or address is not available, then there is no need of this type of data, means data is incomplete .Many times data contain some errors and outliers. Like age attribute with value 260 is an error. The data present in database may be inconsistent. For example, the name of an employee is Ramesh might be stored as Ramesh Kumar in different tables or documents. In that case the data is inconsistent. If the data provided for data mining is not clean, noiseless and consistent, the data mining results will not be accurate and useful. Data cleaning involves a number of techniques including fill the missing values by manual process etc. As a result, data received from data preprocessing steps will be cleaned data.

b) Data Integration: Data is combined and integrated from many resources to get a single database in data integration step. Data stored in various forms in various locations. Data can be stored in various forms like database, word files, sheets, forms, documents, data warehouses, websites and more. This is very tricky and complex task since data is available at different locations in various formats. Metadata is very helpful in data integration. Another problem in this step is data redundancy. Data Integration provides reliable data to maximum capacity by removing data redundancy.

c) Data Selection: As huge data of historical databases used for analysis. In data repository, data is available in large volumes as required. From this huge data, data

of interest is selected for specific purpose. Data selection is the process where data of interest is selected from huge volume of data sources.

d) Data Transformation: Data is being transformed in other form of data. Data transformation can be done by using data normalization, data aggregation and data generalization. For eg, a data set is “5, -37, 110, 87, -48" can be changed to as "0.05, -0.37, 1.10, 0.87, -0.48" by using transformation. After data transformation, data mining can be proceed easily.

e) Data Mining: Data mining is very important and main process combination of various tidy processes which are applied to find Patterns from large data for knowledge representation. Data mining process contains a many tasks like association, classification, prediction, clustering, time series analysis and more.

f) Pattern Evaluation: Useful Interesting patterns are finding out in this step. These patterns are depending on some interesting measures. If any pattern is useful, easily understandable or valid, only then these patterns can be used.

g) Knowledge Representation: Knowledge or information extracted from data has the need to be presented in some applicable manner. There are many visualization techniques available for knowledge representation.

2. LITERATURE REVIEW

- D. Yan, W. Qu, G. Guo and X. Wang (2020) proposed PrefixFPM , A general programming framework that can be used to mine frequent itemsets. Prefix projection is used for utilizing CPU completely while divide and conquer approach is used for dividing workload.
- Titarenko,S.,Titarenko,V.,Aivaliotis,G. & Palczewski,J.(2019), the author developed an algorithm to solve time series problems category, of time stamp uncertainties and without time stamp uncertainties. The algorithm also solved time series with temporal constraints and without temporal constraints. Most widely used algorithm is SPAM for sequential pattern Mining and Robust SPAM are referred and used in this paper. The proposed algorithm is much better as it works faster 20 times by SPAM and 6000 times faster as compared to RobustSPAM.

- Whang(2019) proposed a new data analytic model for MISFP (multi item support frequent pattern) in hadoop based parallel algorithms to attain high efficiency by multi item support frequent pattern. Experimental results reduces the time complexity of parallel algorithm by 38% by using MISFP algorithm in distributed environment.
- MRQAR is first non exhaustive algorithm on MapReduce proposed by Martín in 2018.
- Another non-exhaustive algorithm is G3P-LSC a genetic programming language in MapReduce framework for Frequent pattern mining is proposed by Padillo in 2018.
- Caroro, A.,Sison,A.& Medina,R.P (2018) , the author proposed dual pruned Frequent Pattern growth in this paper. In first pruning, it removes itemsets having minimum support less than minimum support count. In second phase, it removes the nodes which are not satisfying minimum support count. He used modified anti-monotone for second step traversing and developed 2P-FP algorithm for pruning .
- According to Ajinkya Kalaskar, Vishali Barkade (2018), a technique proposed known as Fp-growth algorithm in which information is compressed to form Fp-tree and Fp-tree is used for frequent itemsets. Limitations of more memory and more run time in WSC Algorithm are overcome by Fp Growth Mechanism.
- Dawen Xiahow (2018) , the author discovered hadoop technology that provides better result as compared to MapReduced technique for spatiotemporal Frequent Patterns .In this paper a parallel frequent pattern growth named as MR-PFP algorithm is proposed. Hadoop technology is used instead of MapReduce for parallelization. The results show that MR-PFP is better than earlier Parallel FP-growth (PFP) algorithm to improve efficiency and scalability.
- Mohamed A. Gawwad, Mona F. Ahmed & Magda B. Fayek,(2017), the Author developed an algorithm by using the Buddy Prima algorithm . The Greatest Common Divisor (GCD) is also used in the algorithm. A new technique has been developed for parallelization of Fp growth algorithm. Candidate itemsets are not used for itemsets generation . MapReduce and Spark is used for big datasets to explore parallelization abilities in hardware instead on single node.
- Fan Zhang,Youan Xiao (2017) developed DGFP (Dynamic Grouping Frequent Pattern) aims load Balancing which is the problem in FP Growth .It groups the data set by using dynamic grouping. Load balancing method is proposed in this paper. Algorithm

proposed improves load balancing effectively and reduces the overall efficiency of cluster by 5 to 15%.

- Pei,B.,Wang,X.&Wang.F.(2016), in this paper author proposed an algorithm PNFP to find association rules by using existential probability of itemsets in transactions .PNFP is more efficient as it is parallelized algorithm by using MapReduce framework to deal with big datasets. It minimizes data replication and communication cost of frequent pattern mining.
- Masome Hoseini & Shahraki (2016), the author introduced an algorithm based on transactional database , which are updated every time ,there is need of incremental Association rule Mining algorithm .CanTree (Canonical Tree) is used instead of FP-tree in frequent pattern growth Algorithm which improves efficiency at high mininmum support.
- Min Chen, XueDong Gao(2015) , a new parallel Fp Growth algorithm is proposed by the author to run on cluster system. Projection method is used instead construction of fp tree to find Frequent itemsets. Problem of memory overflow is also solved in this paper. Any data mining task splitted into many subtasks and these subtasks are executed in parallel .After execution the aggregated result is the final result. By this way efficiency and scalability improves much better.
- Gupta and Garg (2011) extends the work on COFI algorithms and show that performance of COFI algorithms lowers in case of sparse dataset.
- El-Hajj and Zaiane (2003) proposed an algorithm based on pruning method. In pruning method data storage can be reduced by cutting down irrelevant itemsets from FP-Tree used in FP-Growth algorithms. These pruning algorithms are called Co-Occurrence Frequent Itemset (COFI) .COFI -tree construction works in top down mining technique. Memory consumption is less as compared to FP-Tree and hence less computation time is needed. Two types of implementations are there in COFI- Tree 1).Non- recursive method is used to generate all frequent patterns . 2).pruning method are used to remove non frequent itemsets, only frequent itemsets are remaining ,however threshold value of minimum support value consider low.

3. DESCRIPTION OF BROAD AREA

Data Mining is the extraction of useful patterns from huge databases. These patterns are used in market basket analysis, which bring revolutionary changes in creating revenue. Frequent patterns are used for association rule mining. Apriori algorithm is used earlier for association rule mining .Association rule mining is used to create interesting patterns.

3.1 Frequent Patterns

Frequent Patterns are the patterns that happen frequently in data. There are numerous types of frequent patterns. A lot of frequent itemsets occurs frequently in transactional databases which provide useful information for decision making. For example, pencil and eraser, which are frequently purchased together in markets by various buyers. A frequently occurring subsequence, for example, another frequent pattern that buyer, purchased a PC, along with computerized camera, and then a memory card, is a (Frequent) consecutive pattern. There are many different consecutive sequences of these frequently itemsets.

3.2 Association Rules

Association rules are used to find association between unrelated itemsets in transactional databases. These association rules are used for analysis and prediction of customer or buyer's interest .The association rules are used for market basket analysis which can give beneficial results and make revenue to the authorities. Support and Confidence are widely used for generating association rules. Support threshold and Confidence threshold are used to calculate frequent itemsets. Values of these thresholds are decided by user. For example: In 60% of the cases, when customers buy milk, they also buy sugar. This shows the association between milk and sugar. We can represent it as: milk->sugar| 60% association

3.3 Interesting and Useful Patterns

A Data Mining framework can possibly create thousands or even a huge number of examples, or rules.

Let A={a_1 , a_2, a_3,……,a_{d}} is collection of different item's in a market.

T= {t_1,t_2,t_3,t_4……t_n} are some transactions of the store. Any transaction is made up by collection of some items chosen from itemset A. In association analysis, k-itemset is collection of k items from itemset A. For example, any transaction t_i = {milk, bread, sugar} has 3 items then it is 3-itemset.Null itemset having zero items. Association analysis is used to find relationship between different items in voluminous data. Support and Confidence are two coins used to find interesting and useful patterns. Support determines how often any association rule is applicable to dataset. Confidence represents how frequently item appears in transaction. Strong association rules are selectively those rules having support and threshold value greater then user specific minimum support and minimum threshold values.

3.4 Efficiency and Scalability

Efficiency and scalability are constantly viewed as when contrasting information Mining calculations. As information sums keep on duplicating, these two elements are particularly basic. Efficiency and scalability of information Mining calculations: Data mining calculations must be productive and versatile so as to viably separate data from tremendous measures of information in numerous information archives or in powerful information streams. As it is, the running time of an information mining calculation must be unsurprising, short, and worthy by applications. Efficiency, scalability, execution, advancement, and the capacity to execute continuously are key criteria that drive the improvement of numerous new information mining calculations, parallel, appropriated, and gradual mining calculations. The huge size of numerous informational indexes, the wide storage of information, and the computational power of certain information Mining strategies are factors that affect the improvement of parallel and circulated information escalated mining calculations. Such calculations first segment the information into "pieces." Each piece is handled, in parallel, via looking for

designs. The parallel procedures may collaborate with each other. Distributed computing and group figuring, which use PCs in a cooperative manner to handle enormous scale computational data, are likewise dynamic research subjects in parallel information mining. The significant expense of certain information Mining forms and the gradual idea of information advance steady information mining, which consolidates new information refreshes without mining the whole information "without any preparation." Such techniques perform information alteration steadily to correct that is recently found.

4. Research Gaps

The literature survey discussed in section 2 provides the various algorithms for Frequent Pattern Mining. There are still gaps which are as follows.

I. Effective pruning method can be used by removing irrelevant patterns to improve efficiency and speed of Frequent Pattern Mining Algorithms.

II. Dual pruning based on constrained frequent pattern can be used to remove unnecessary load on memory to retain irrelevant frequent patterns , further enhance the efficiency of FPM algorithms in terms of space and memory.

III. An enhanced algorithm can be developed to overcome various issues like memory, efficiency and scalability in FPM algorithms.

IV. Since the databases are updated every time, so incremental Frequent Pattern Mining is required.

5. OBJECTIVES OF THE STUDY

In view of the limitations of the existing algorithm, the objectives of our study shall be

1. Analytical study of existing Frequent Pattern Mining Algorithms proposed by various researchers.
2. Identification of an effective Pattern pruning method to retain high quality Pattern.
3. Propose an algorithm for Frequent Pattern Mining framed into parallel and distributed environment to balance the workload of single node.
4. Validate the proposed algorithm using real datasets.

6. METHODOLOGY TO BE ADOPTED

In the first phase, we will identify factors that impacts the Frequent Pattern Mining and in the second phase pruning technique will be used for removing irrelevant itemsets effectively. Hadoop technology will be used to develop a new algorithm for Frequent Pattern Mining framed into parallel distributed environment to balance the workload of single node, .In Hadoop environment we will use real time dataset to validate our proposed algorithm and comparison with existing algorithms.

7. EXPECTED OUTCOME OF THE RESEARCH

Pruning of irrelevant itemsets will help in developing efficient algorithm for Frequent Pattern Mining. After pruning of irrelevant itemsets, resultant algorithm will be useful for FPM in big datasets. Proposed algorithm will consume less memory, time and cost as compared to existing Frequent Pattern Mining algorithms. Parallel and distributed file processing will help in less usage of CPU to read and write data form cluster.

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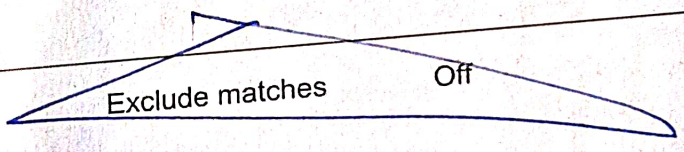

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